



Derivation of aerosol properties from A-Train observations

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LOA/CNRS/Université de Lille 1

Contributions from: F.M. Bréon, Y. Derimian, O. Dubovik, D. Josset, N. Loeb, J. Pelon, S. Peyridieu, L. Remer, W. Su, O. Torres, F. Waquet, D. Winker, H. Yu, T. Yuan

WHERE DO WE GO FROM HERE?

Long term data series

Lidars, wide spectral polarimeters

2010?

2009

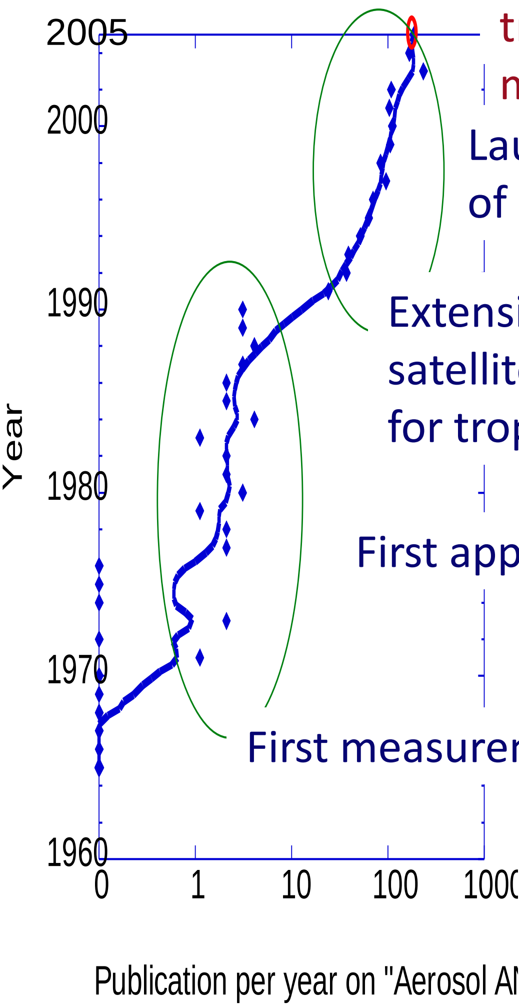
Multi-satellite analysis <--> transport and climate models

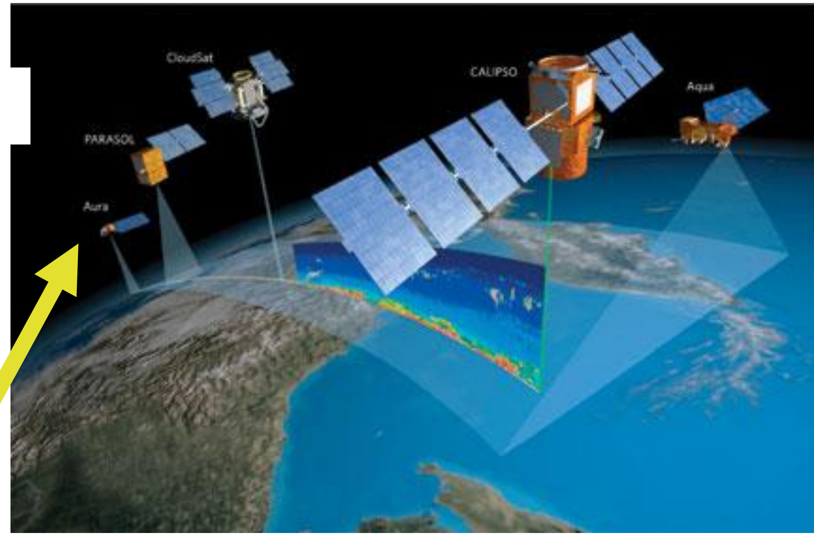
Launch and desing of aerosol sensors

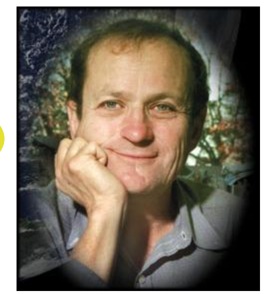
Extensive use of satellites not designed for trop. aerosol

First applications

First measurements







Climate change

Hydrology

Radiation

Chemistry

Aerosols

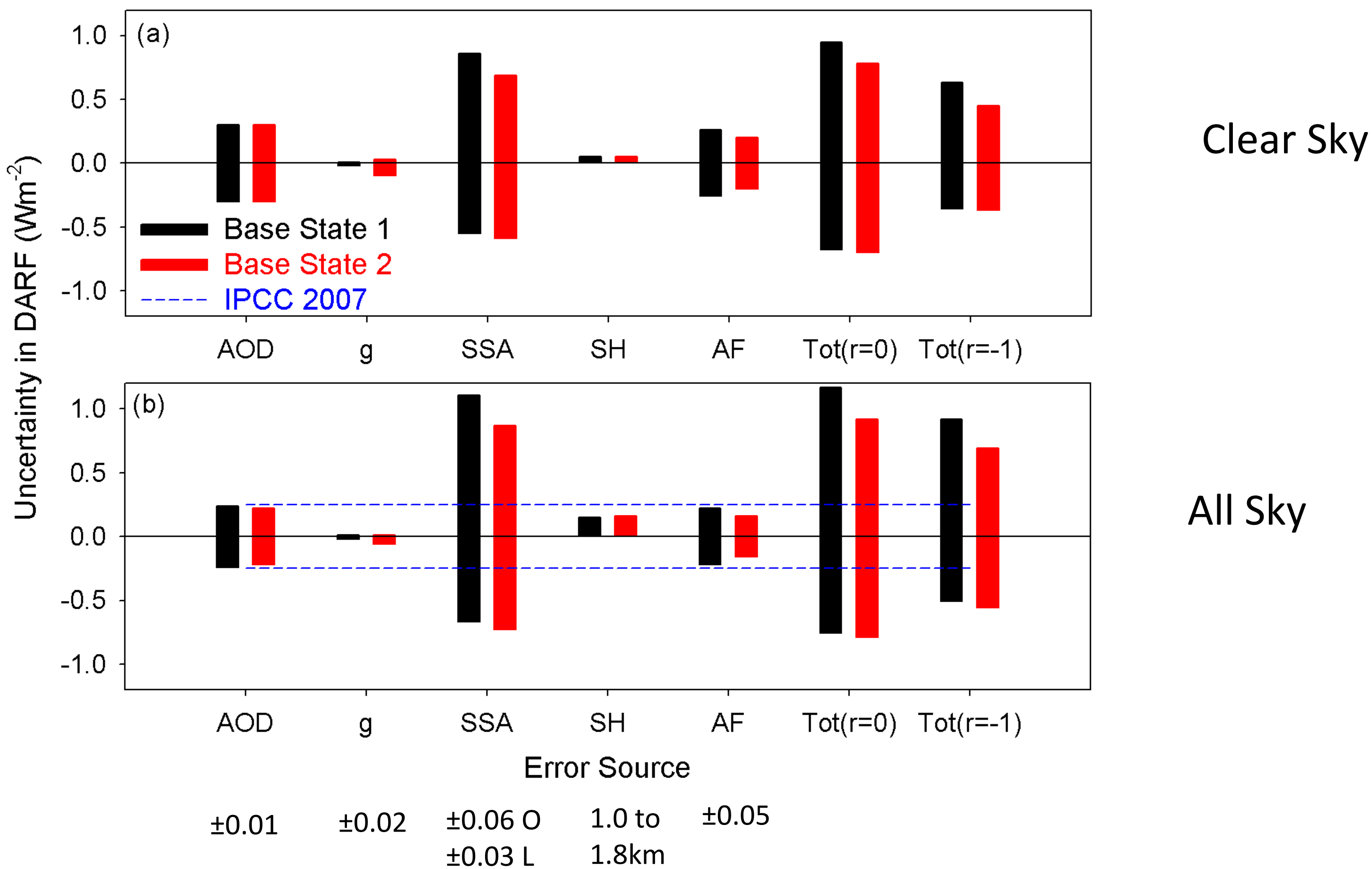
Clouds

precipitation

Surface

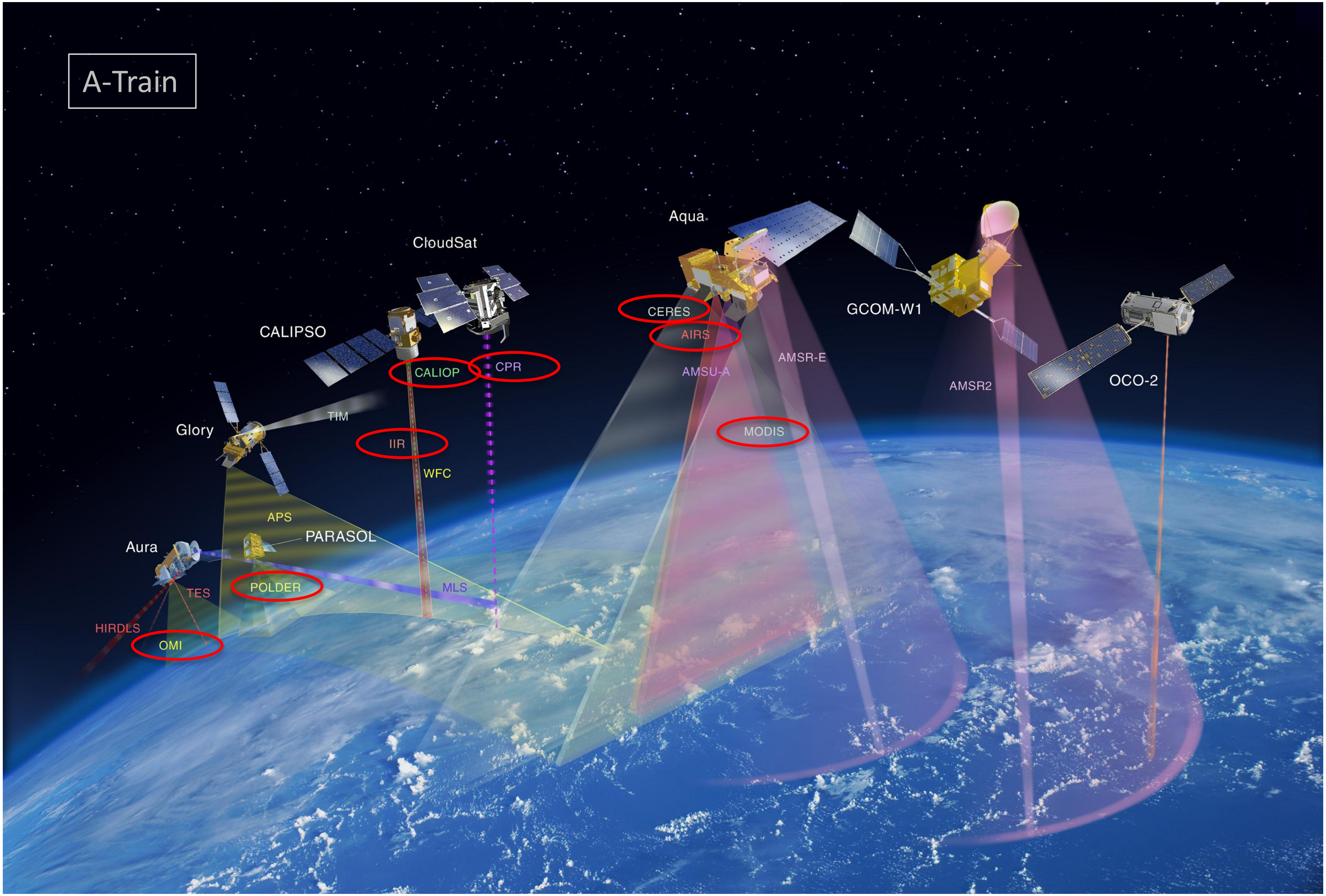
“Space-borne Observations of Aerosols - how it all began.”
From Y. Kaufman, AGU, 2005

Increase our knowledge of aerosol climate system



Perturbation analysis: Loeb and Su, J.Clim., 2010

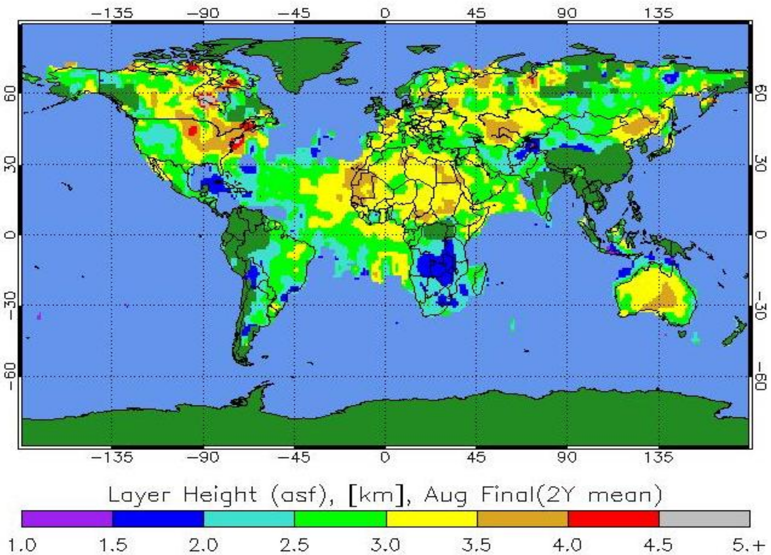
A-Train

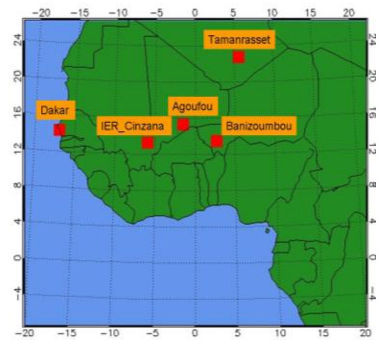

Aqua
CloudSat
CALIPSO
GCOM-W1
OCO-2
Glory
Aura
PARASOL
CERES
AIRS
AMSR-E
AMSU-A
AMSR2
CALIOP
CPR
TIM
IIR
MODIS
WFC
APS
POLDER
MLS
TES
HIRDLS
OMI

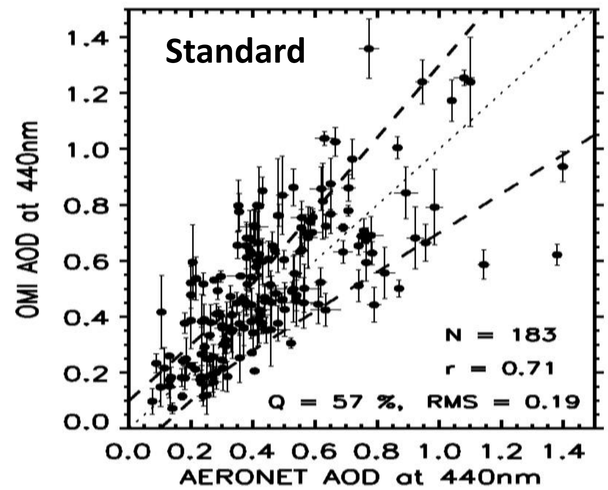
OMI/CALIOP

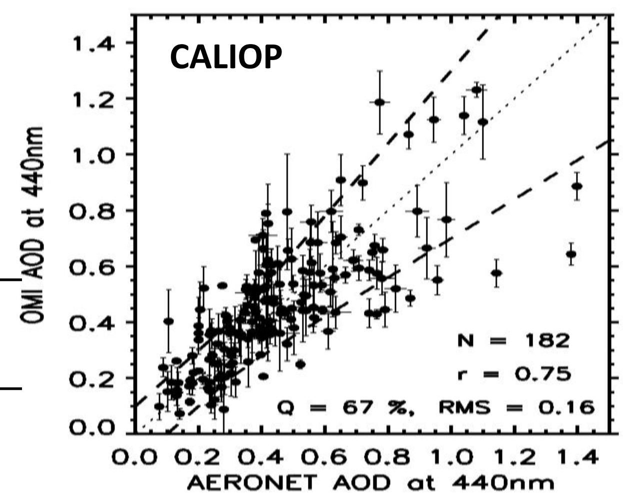
Improved OMAERUV-AOD Accuracy when using CALIOP-based climatology of Aerosol Layer Height

August Average Aerosol Layer Altitude









OMAERUV-AERONET at Banizoumbou

OMAERUV-AOD validation using standard and CALIOP-based aerosol layer height

$Q_{10(30)\%}$ Percent of points within 10(30)% of AERONET

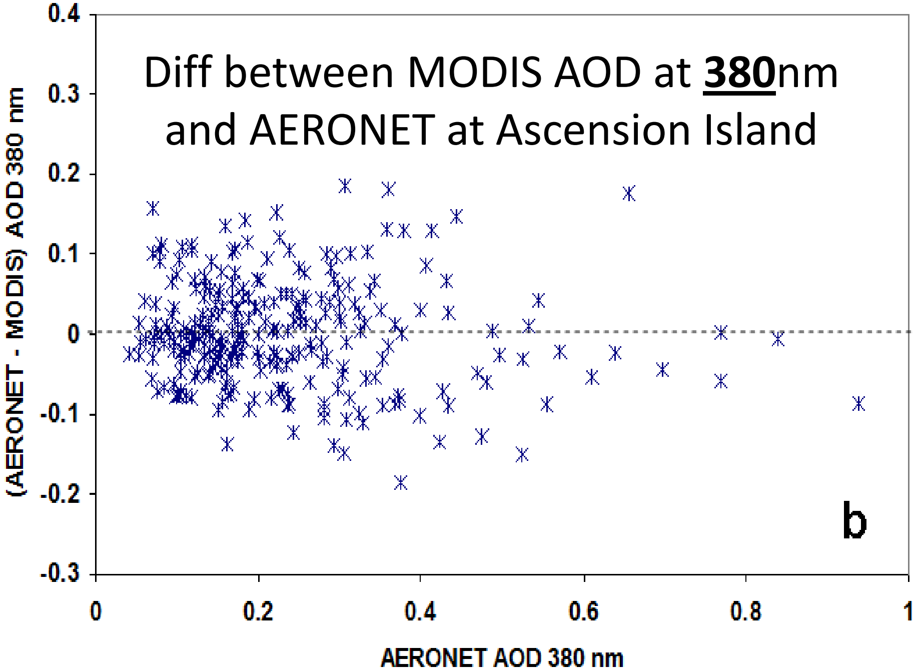
AERONET Site	R Std	R Cal	Intercept Std.	Intercept Cal	RMS Std.	RMS Cal	Q_{10} Std	Q_{10} Cal	Q_{30} Std	Q_{30} Cal
Agoufou	0.82	0.83	0.13	0.10	0.17	0.16	50	58	64	71
Tamanrasset	0.83	0.84	0.09	0.08	0.10	0.10	60	63	66	69
Banizombou	0.71	0.75	0.21	0.17	0.19	0.16	45	53	57	67
Dakar	0.73	0.74	0.14	0.12	0.19	0.15	39	56	58	69
IER_Cinzana	0.79	0.83	0.09	0.08	0.21	0.17	35	47	50	60

Measurable improvement in all statistical parameters

From O. Torres

OMI/MODIS

Satheesh et al. (2009)

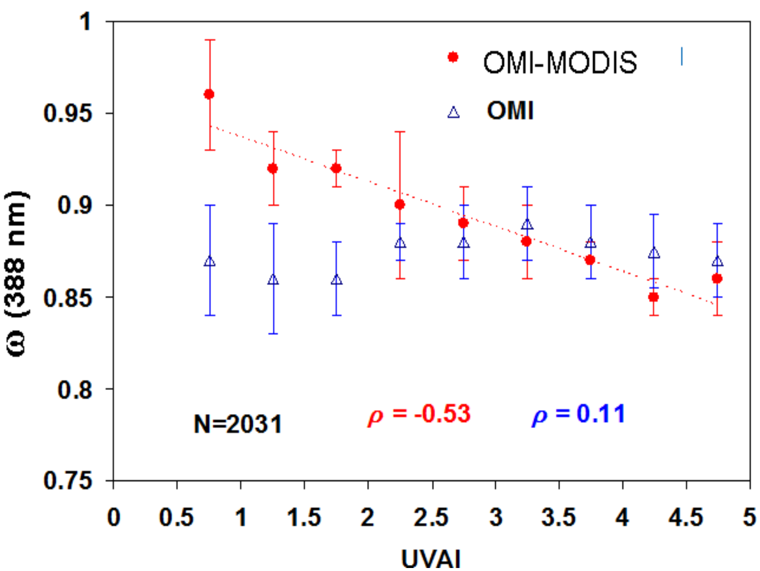


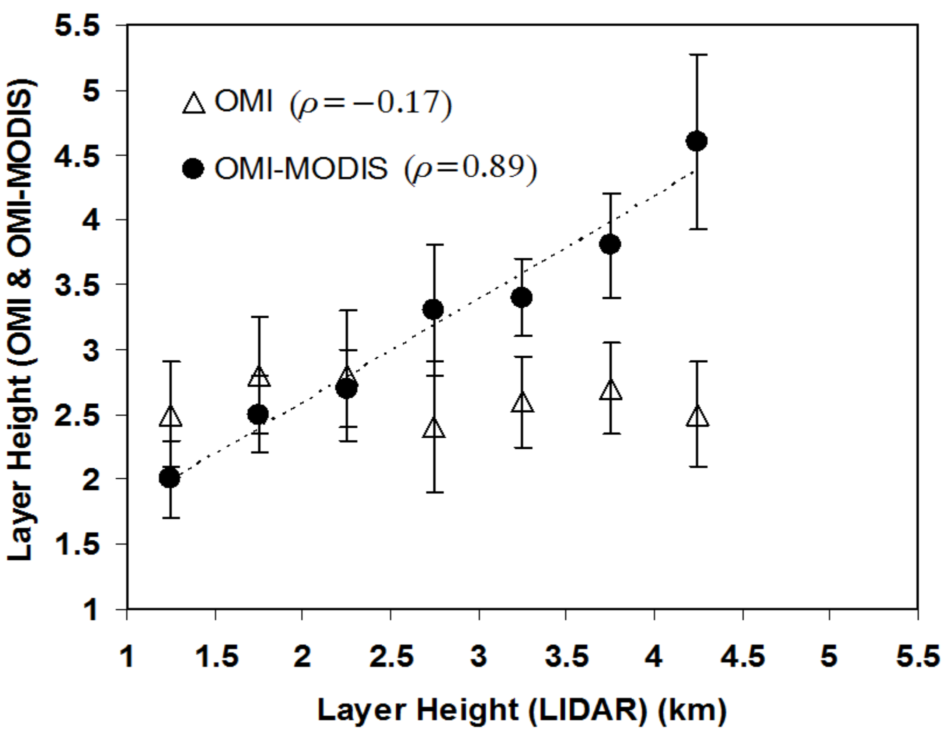
Use MODIS to constrain AOD

Allow OMI to retrieve aerosol layer height and ω_o

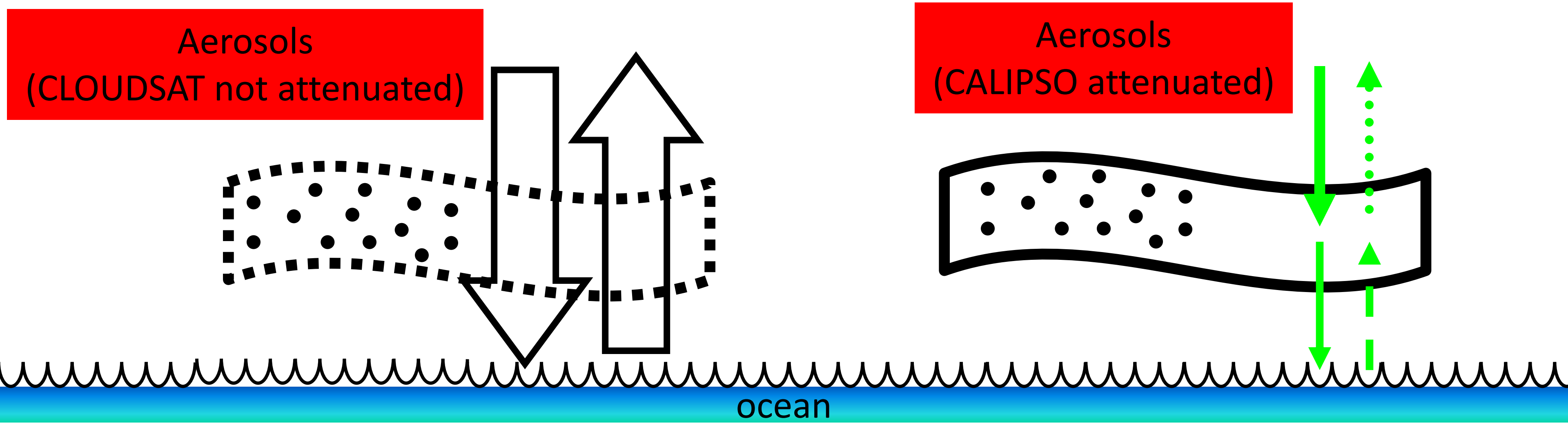
Results are much improved over the OMI retrieval without the MODIS constraint

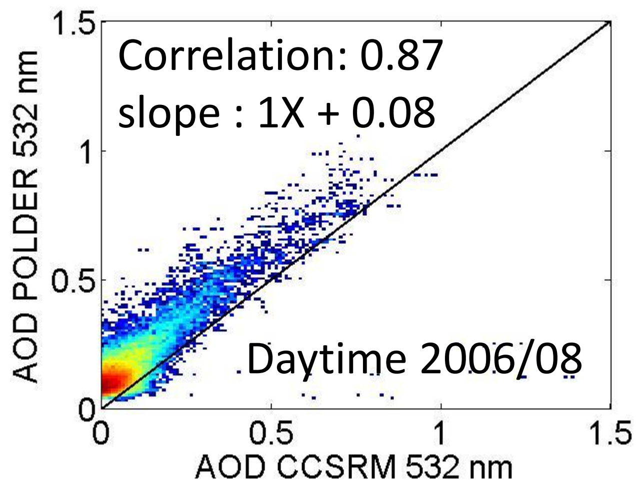
Layer height

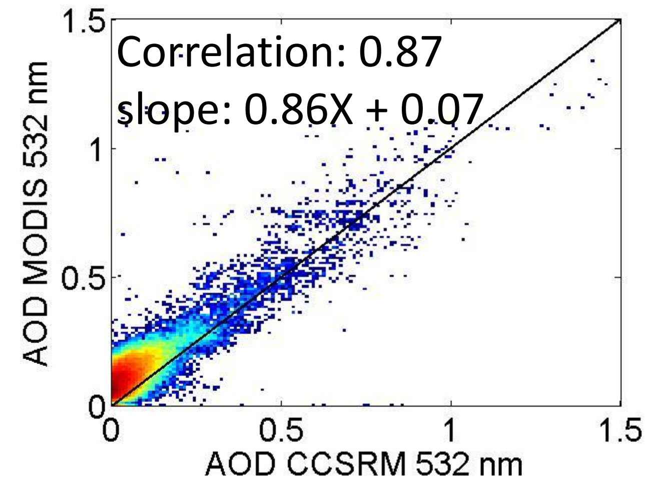




CLOUDSAT and **CALIPSO** allow to directly retrieve aerosol optical depth above ocean surface (D. Josset presentation on Thursday)







Cloudsat-radar provides reference to measure CALIPSO-lidar attenuation

First version of ocean surface algorithm shows really good agreement with **PARASOL and MODIS**

Works nighttime, no assumption on aerosol properties

Improvements resulting from utilization of statistical optimization principles

(O. Dubovik presentation on Thursday)

Both bi-directional intensity & polarization reflectance and aerosols are retrieved simultaneously

f_j^* - PARASOL data:

Angular measurements (~15 angles) of

- ***Intensity*** (λ = 0.49; 0.67; 0.87; 1.02 μm)
- ***Polarization*** (λ = 0.49; 0.67; 0.87 μm)

a_j - Parameters to be retrieved:

-***Aerosol*** propetries:
- size distribution; - real refractive index
- imaginary refractive index; - particle shape

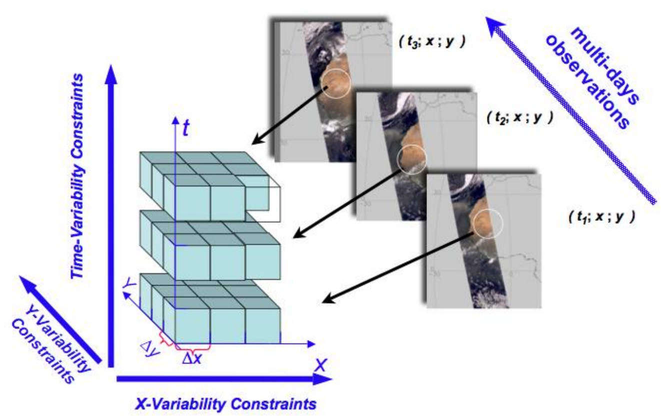
-***Surface*** properties (***over land***):
- BRF parameters; - BPRF parameters

Single - Pixel Retrieval:

$$\begin{cases} f_j^* \\ 0_j^* \end{cases} = \begin{pmatrix} \mathbf{F}_j \\ \mathbf{D}_j \end{pmatrix} \mathbf{a}_j + \begin{matrix} \Delta_j^m \\ \Delta_j^a \end{matrix}$$

A Priori Constraints limiting derivatives (e.g. *Dubovik 2004*) of

- ***for aerosols*** (e.g. in AERONET, *Dubovik and King 2000)* **:**
  - aerosol size distribution variability over size range;
  - spectral variability of complex refractive index;
- ***for surface*** (e.g. in AERONET/satellite retrievals, *Sinuyk et al. 2007)* **:**
  - spectral variability of BRF/ PBRF parameters.



Multi-term LSM ***Multi-Pixel Solution:***

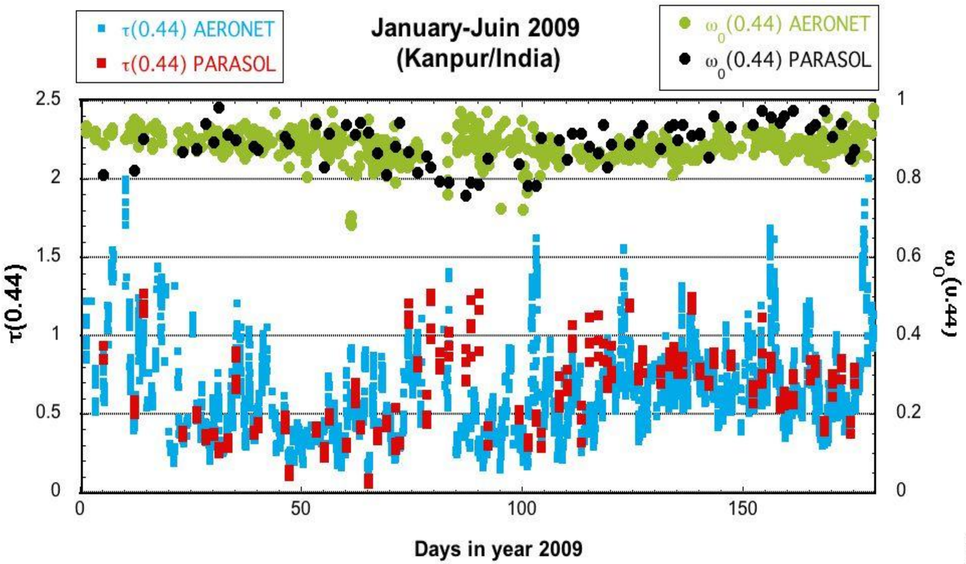
Multi-Pixel a priori constraints (*e.g.Dubovik et al. 2008*):

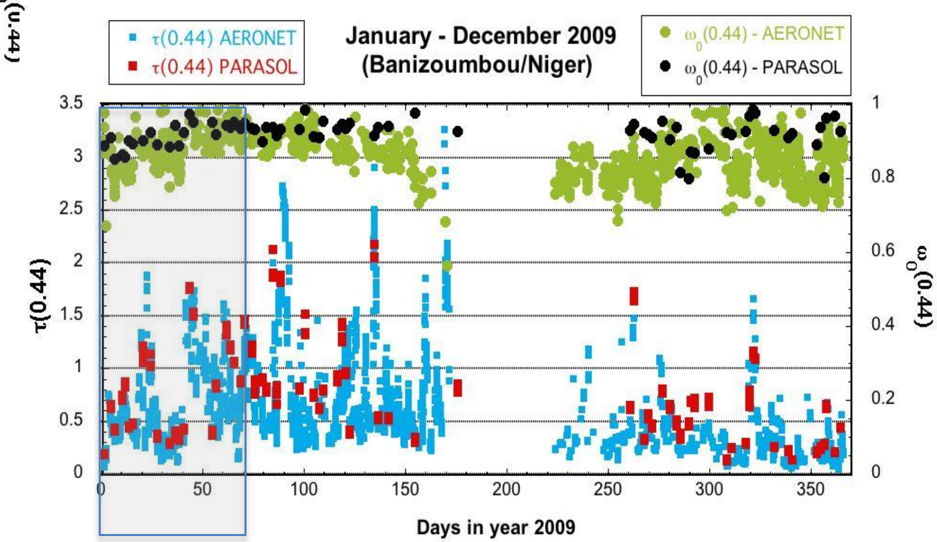
- limited ***spatial*** variability of each aerosol /surface parameter
- limited ***temporal*** variability of each aerosol /surface parameter

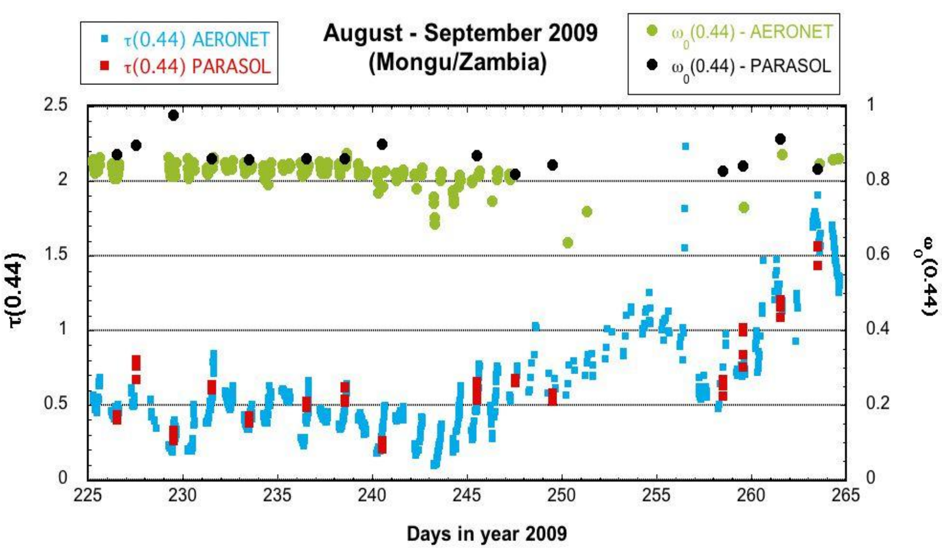
NOTE: *degree of variability constraints (smoothnes) can be different and adequately chosen for each parameter*

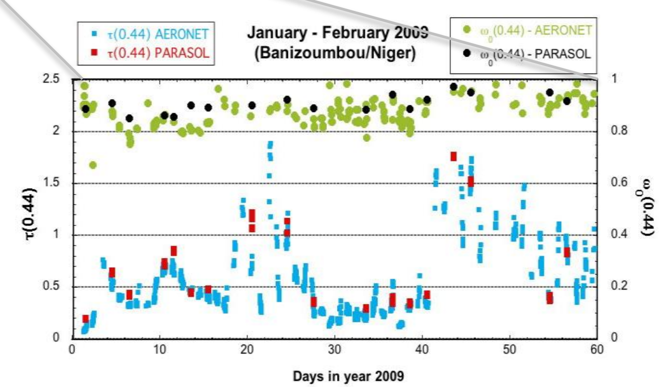
NEW INVERSION

Dubovik et al., 2010

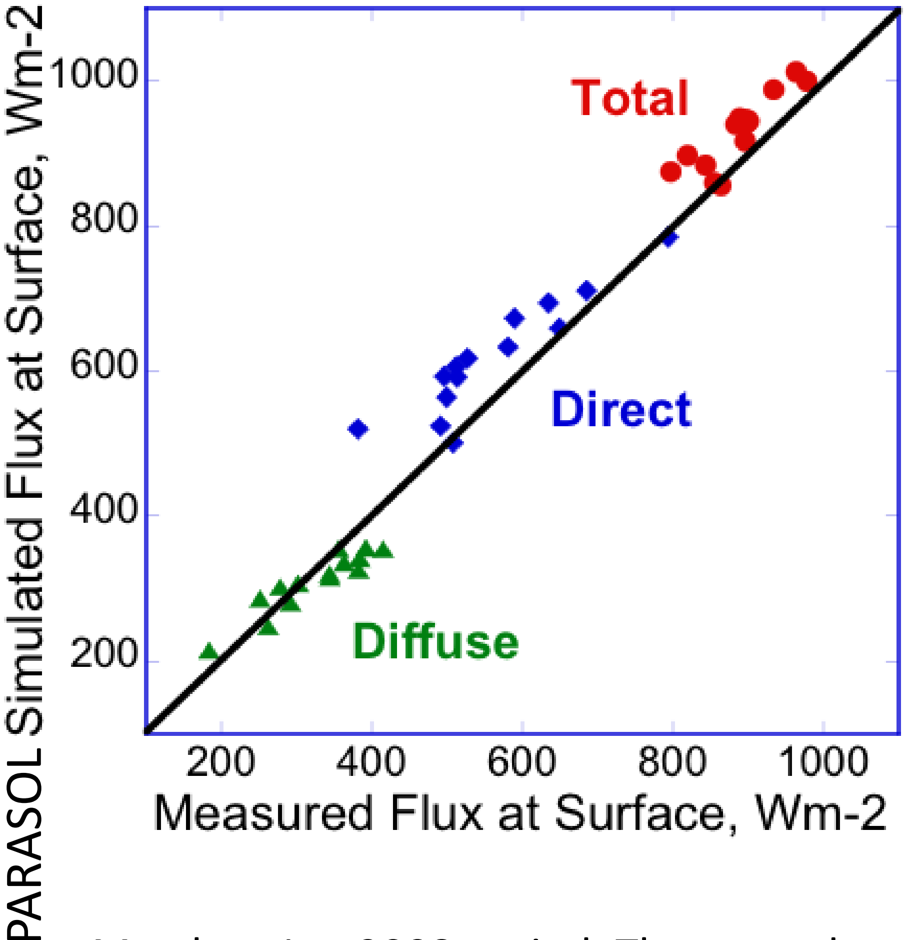






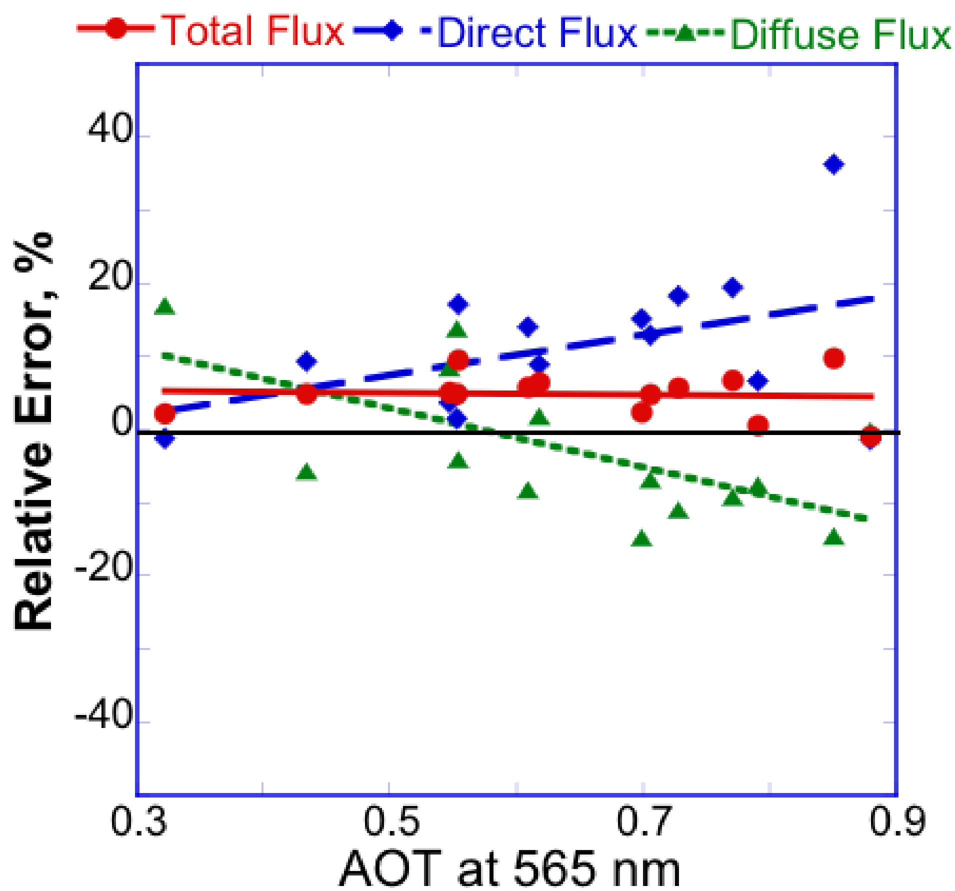


NEW INVERSION



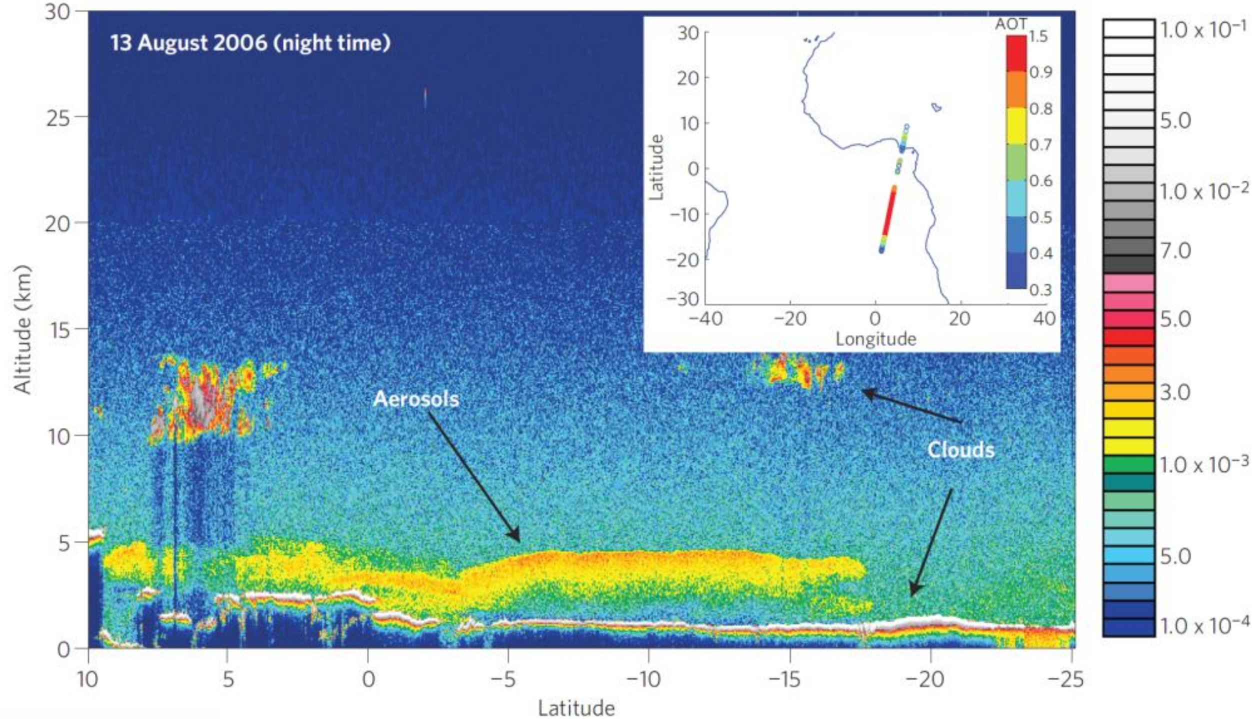
Since surface and atmosphere properties are retrieved, Flux can be derived.

Very Preliminary results for flux at the BOA. Comparison with ground-based measurements in M'Bour, Sénégal.



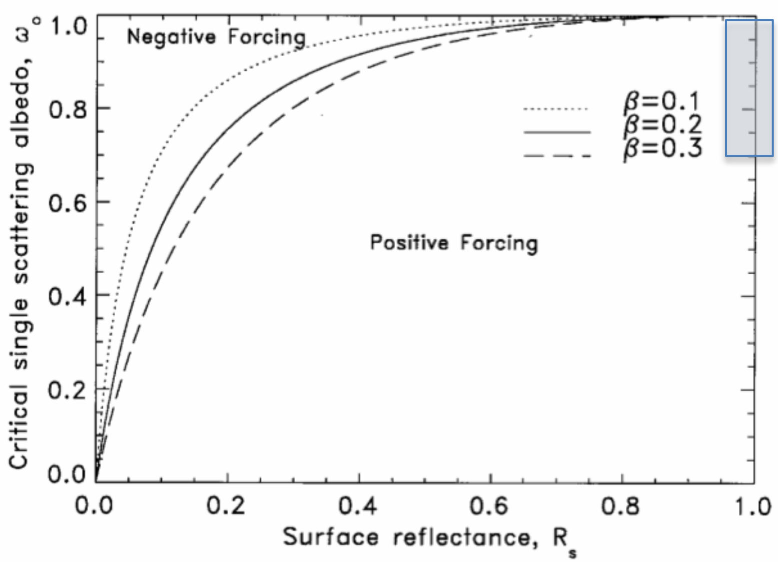
March to Jun 2008 period. The ground-based measured flux is synchronized with Parasol within ±1min.
Gaz content (O3, CO2, etc) are taken from climatology, H2O from AERONET.

Derimian et al., in prep.



(Chand et al., 2009)

Ocean Land Clouds



(Haywood and Boucher , 2000)

Smoke above the persistent stratus deck west of Namibia

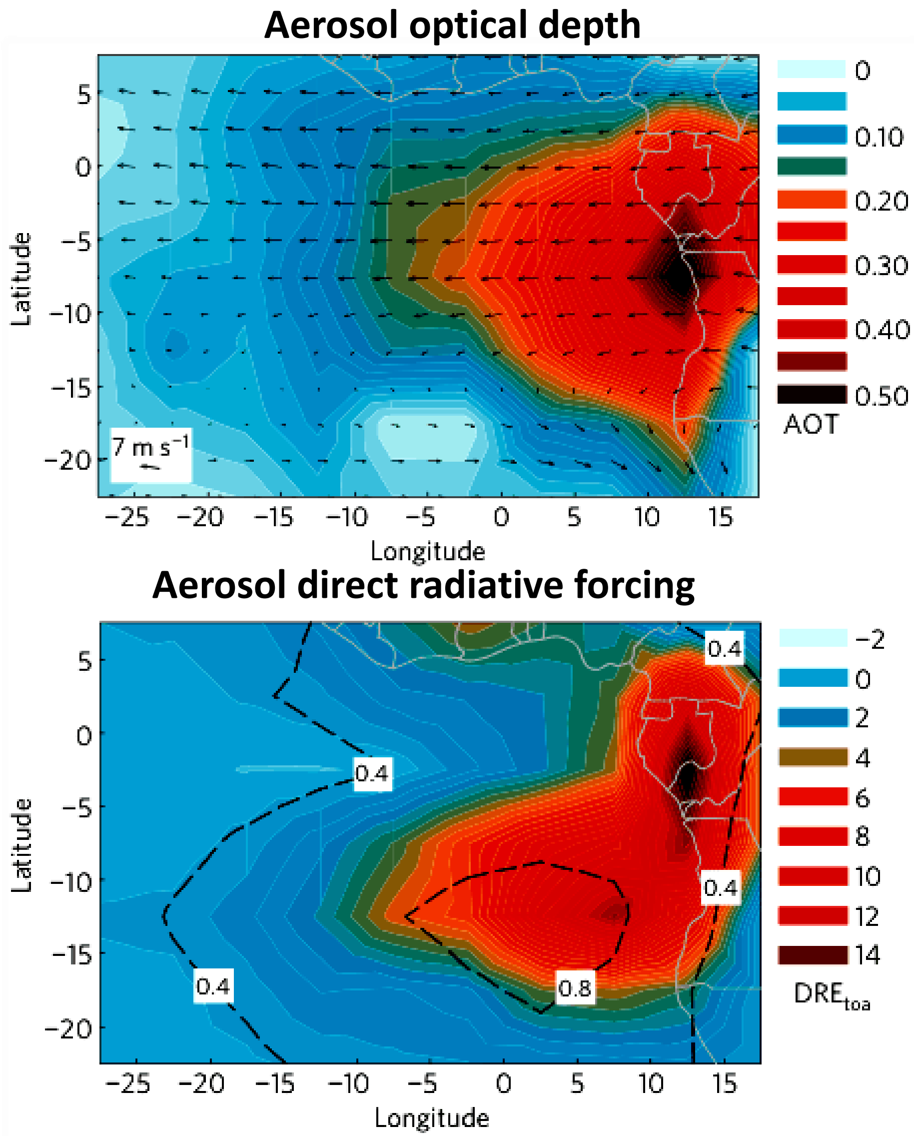
Positive Forcing?

Observational estimates of direct radiative forcing from aerosol above cloud

CALIOP Data from each month (July–October) for the years 2006 and 2007

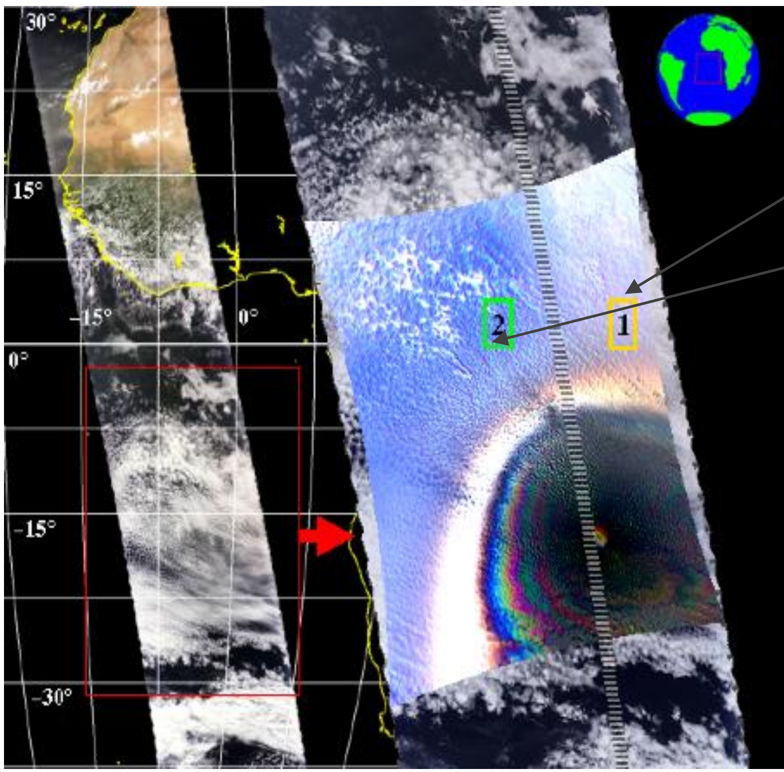
Top right: mean optical depth of aerosol above clouds

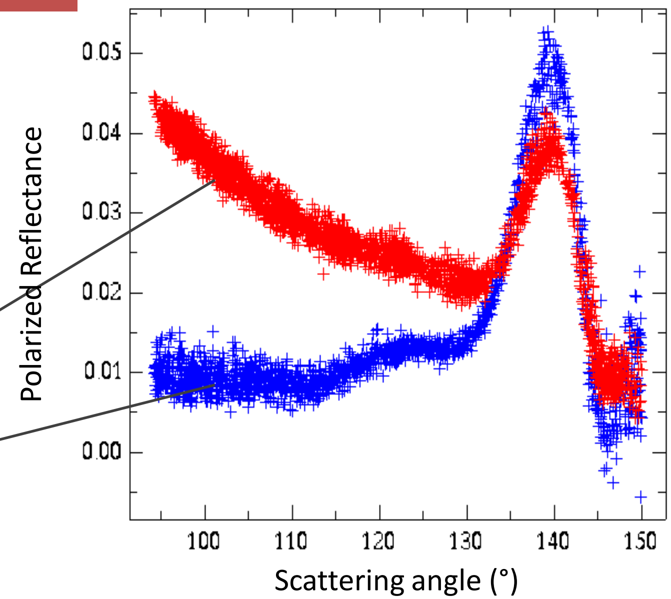
Bottom right: direct radiative forcing from elevated aerosol; aerosol forcing is modulated by cloud cover (contours)

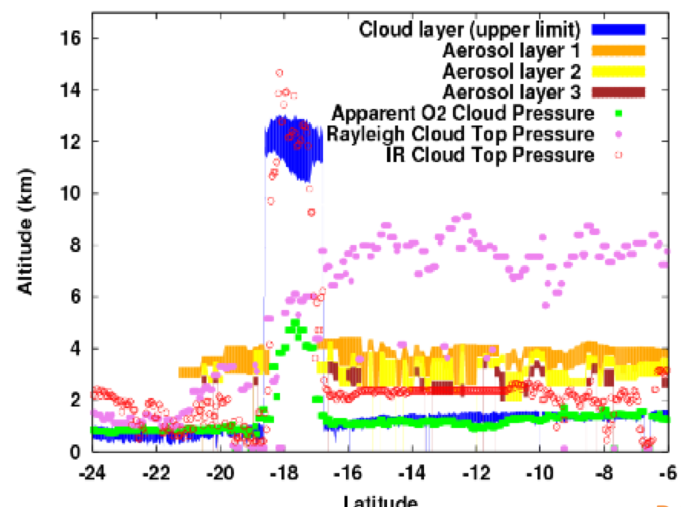


(Chand et al., Nat. Geosci., 2009)

Fine Aerosols above a cloud deck (liquid phase) from PARASOL



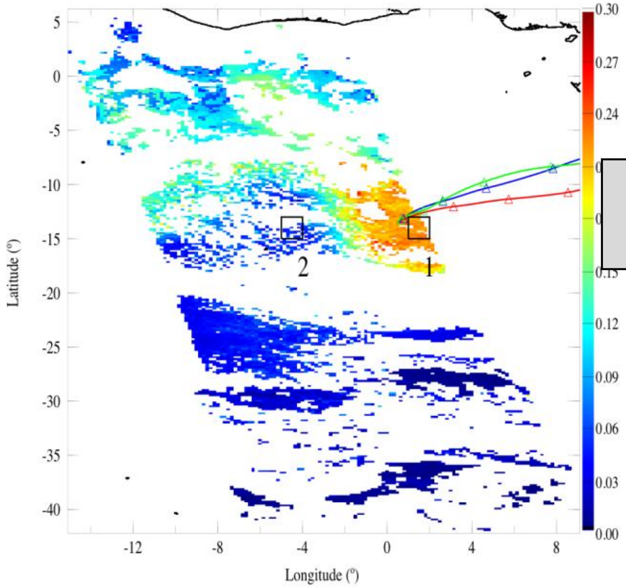




August, 18 2006

Waquet et al., 2009

Aerosols above a cloud deck

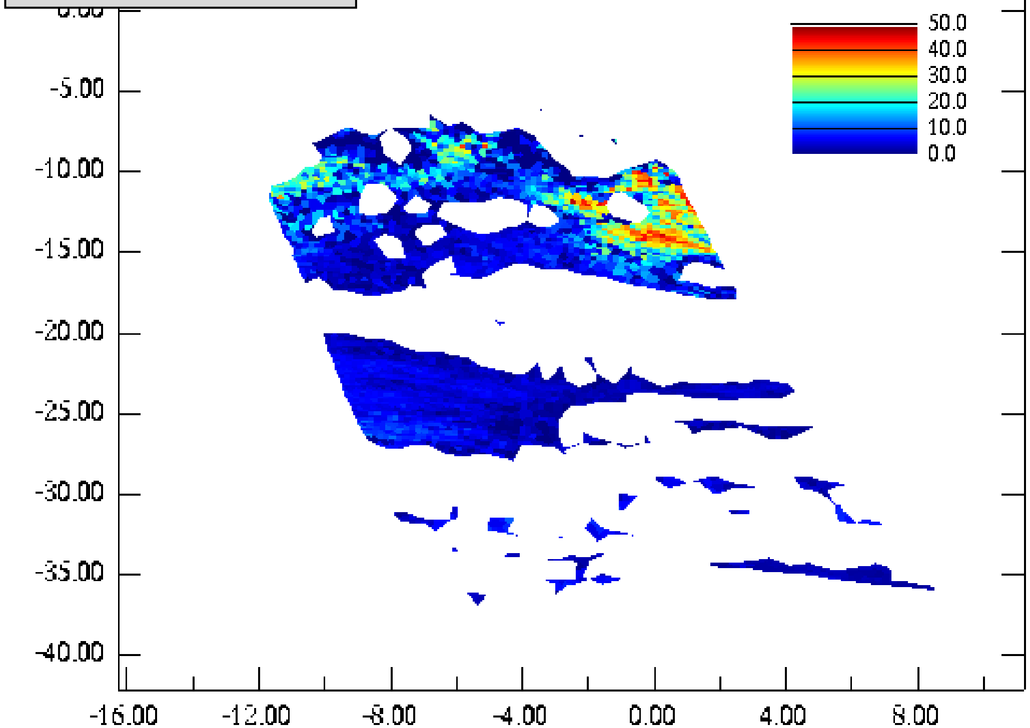


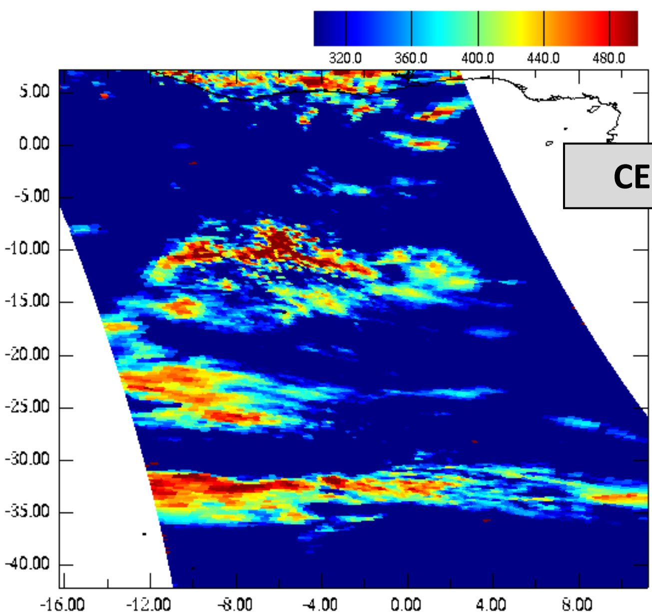
PARASOL AOD

POSITIVE AEROSOL FORCING

forçage

PARASOL :AEROSOL
+
MODIS: CLOUD

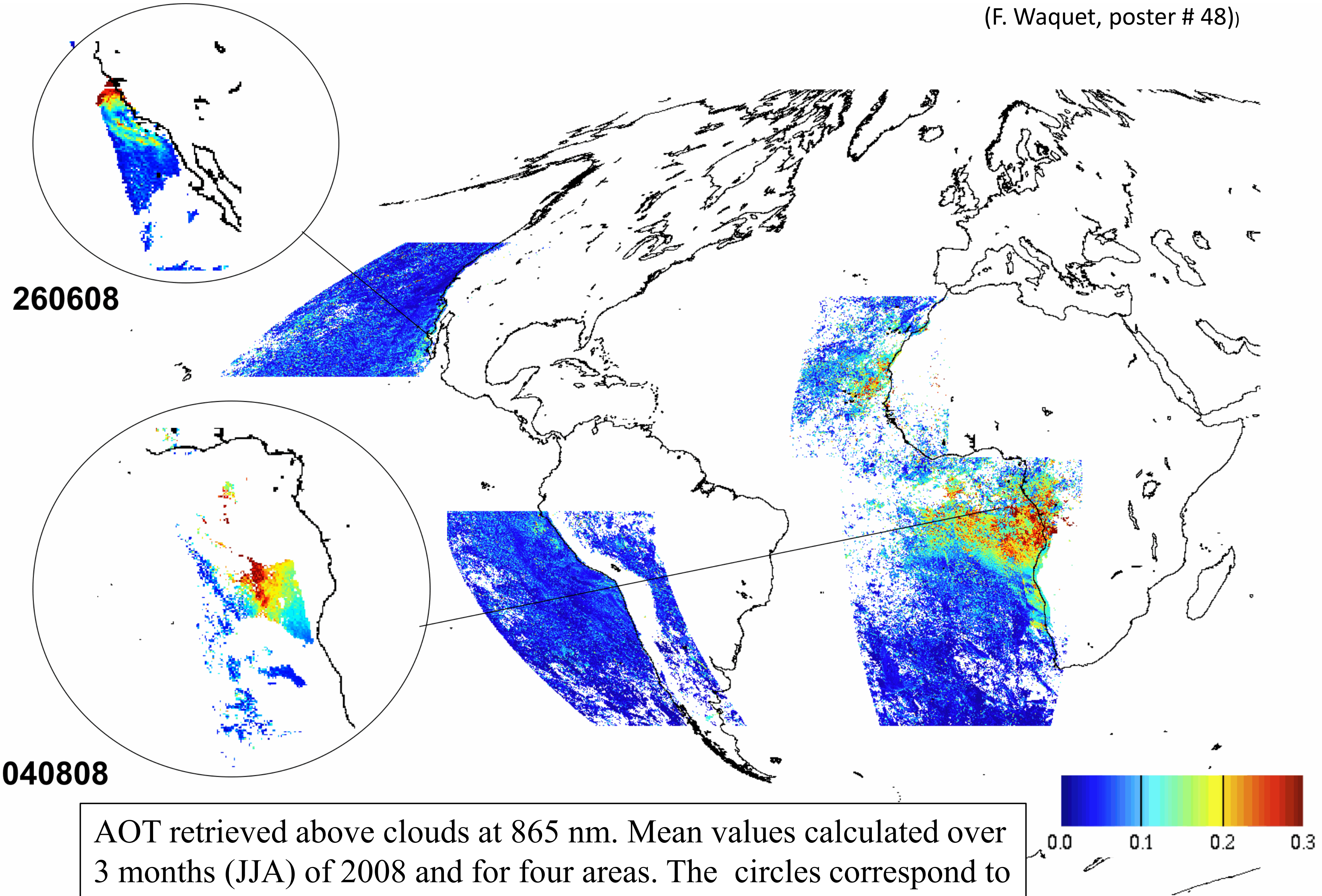




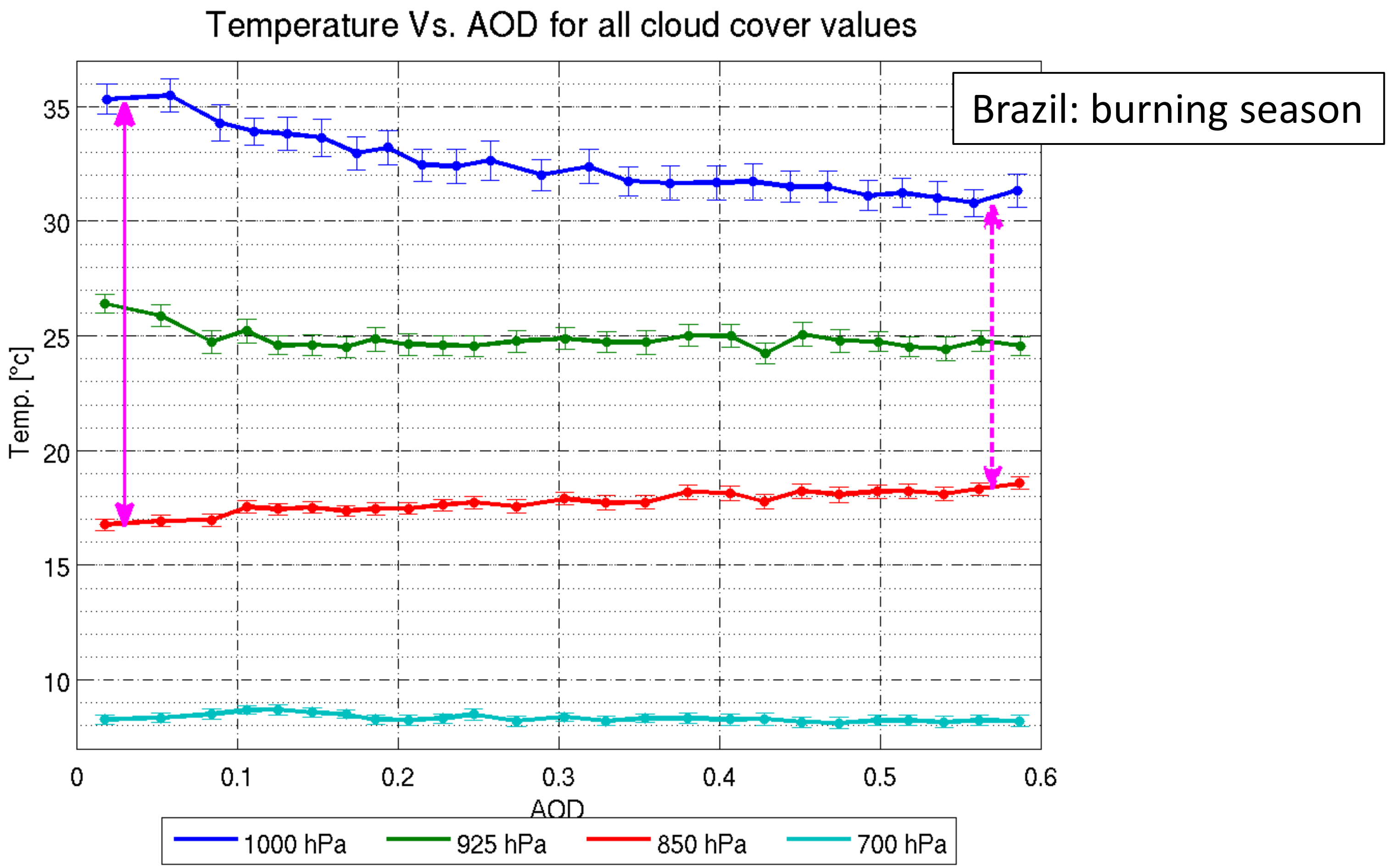
CERES

Waquet et al., in prep.

(F. Waquet, poster # 48))

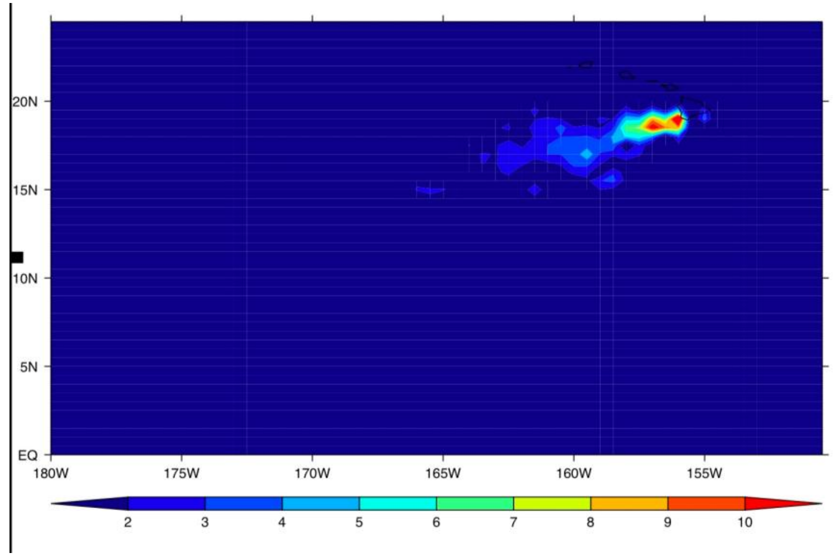


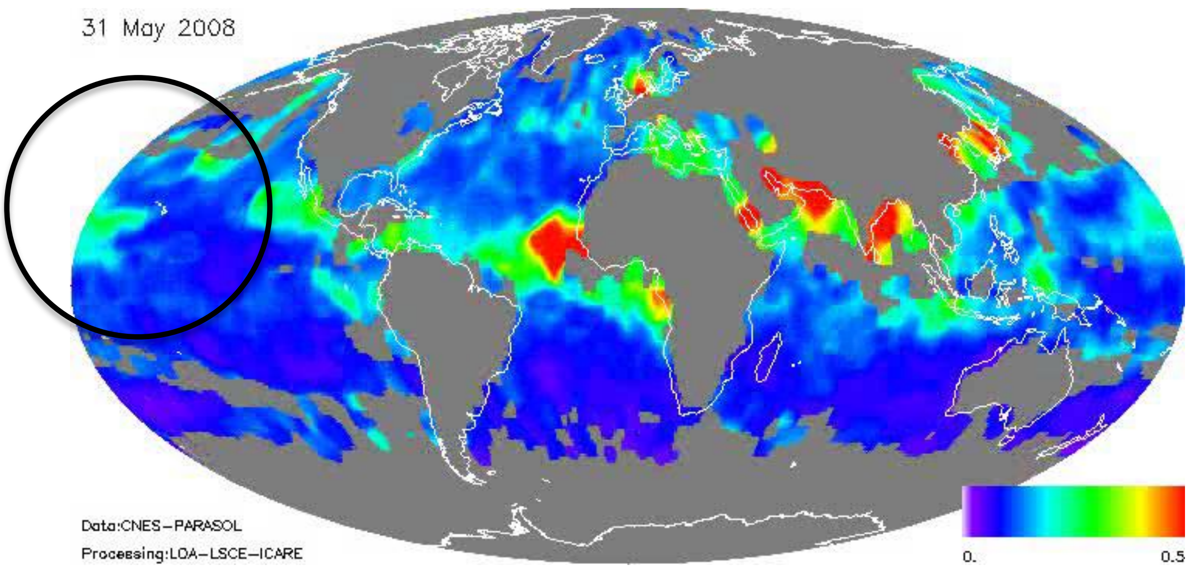
AOT retrieved above clouds at 865 nm. Mean values calculated over 3 months (JJA) of 2008 and for four areas. The circles correspond to daily observations.



AIRS temperature profiles combined with MODIS AOD shows response of the atmosphere (changes of stability) to aerosol effects.
At 1000hp, 5° decrease due in part of the effect is aerosol changing cloud cover and shading the surface.
At 850hp, 1.5° increase due to aerosol absorption. (Davidi et al. ACP, 2009)

JJA 2008 mean SO_2 concentration retrieved from OMI assuming that gas is within PBL. The unit is in Dobson Unit



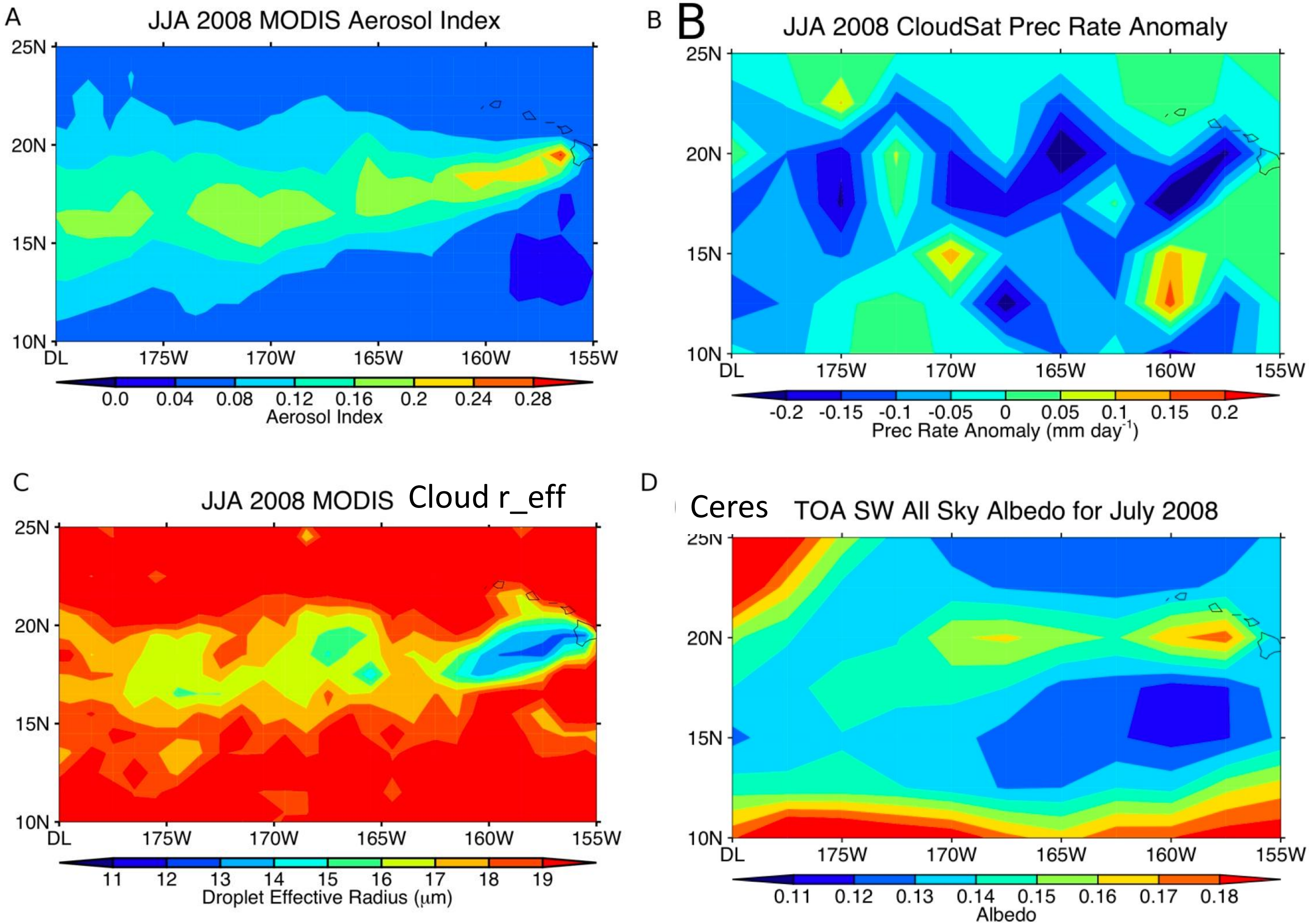


The Halemaumau Crater of the Kilauea volcano on the Big Island of Hawaii began venting SO2 gas in March 2008

PARASOL AOD

Yuan et al., (submitted to Science)

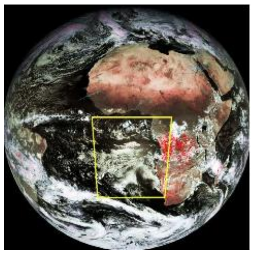
Volcano tracks (Yuan et al., Submitted to Science)

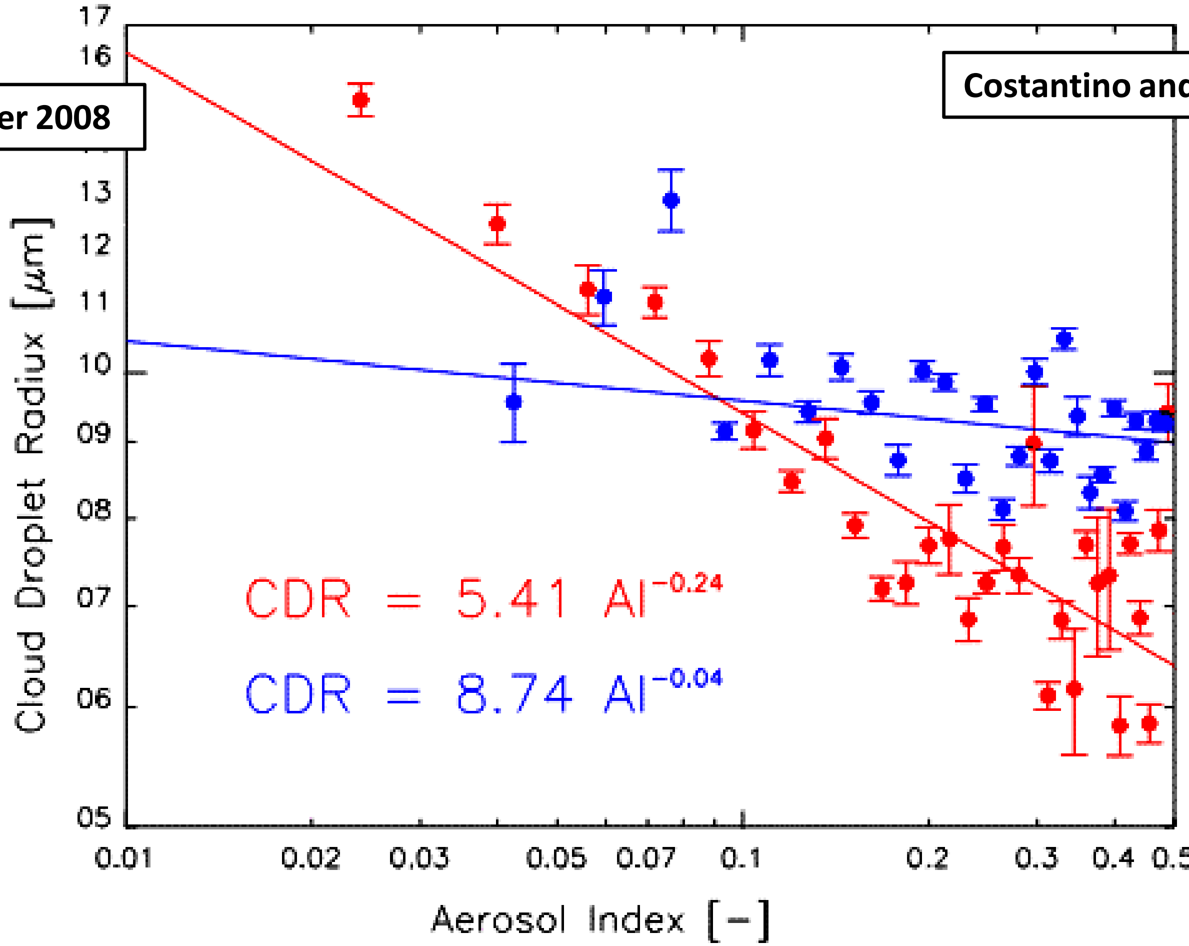


INDIRECT EFFECT

June2006-December 2008

Costantino and Breon, GRL, 2010





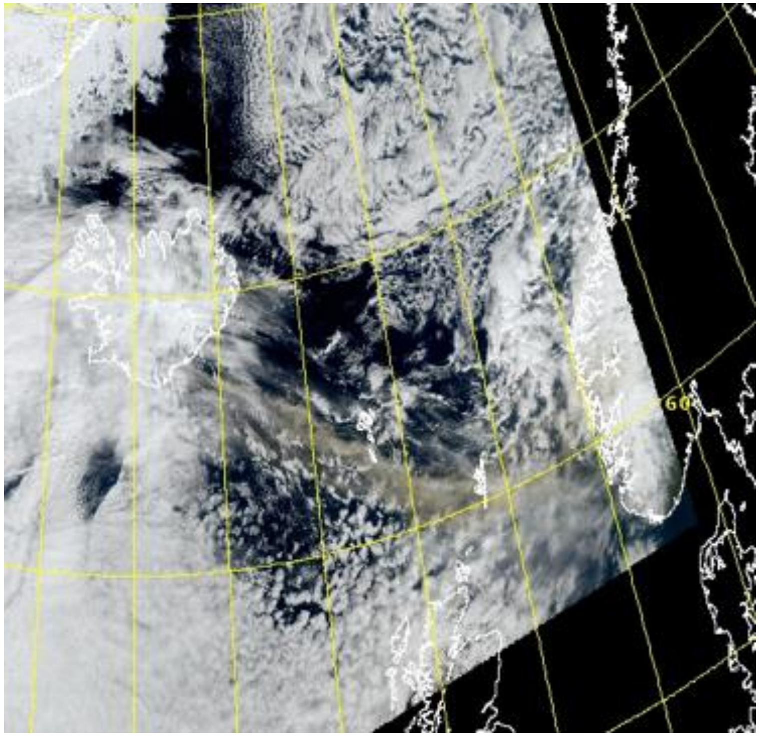
1st Indirect effect: more aerosol produces smaller cloud droplets

this study uses cloud droplet size from PARASOL and aerosol index from MODIS, CALIPSO is used to identify when the smoke layer is in contact with the cloud deck and when it is vertically separated

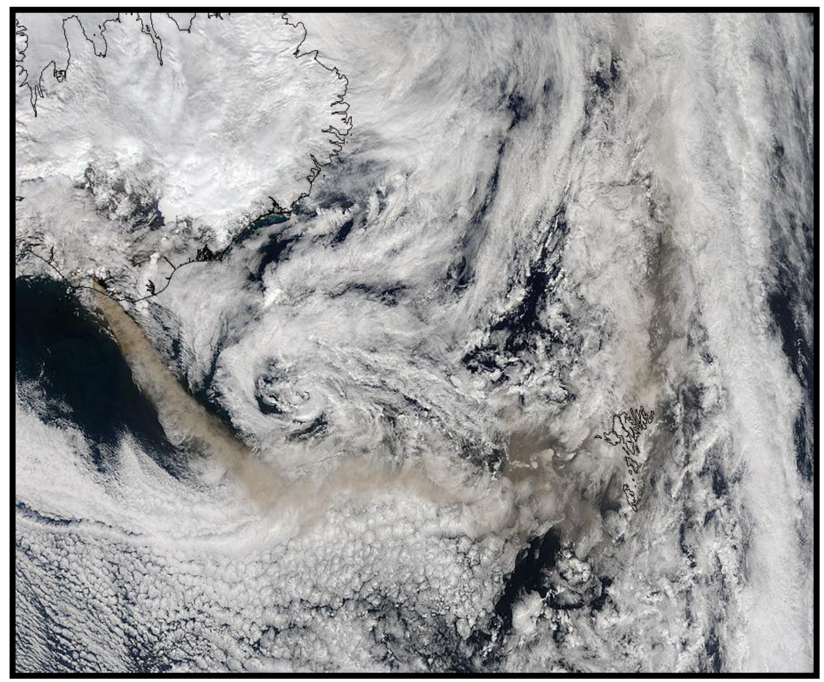
Blue – Separate layers: indirect effect appears to be small

Red – when CALIOP is used to confirm aerosol is in contact with cloud: indirect effect consistent with theory

Eyjafyallajökull volcano



Aqua-MODIS 15 April 2010 at 1330 UTC



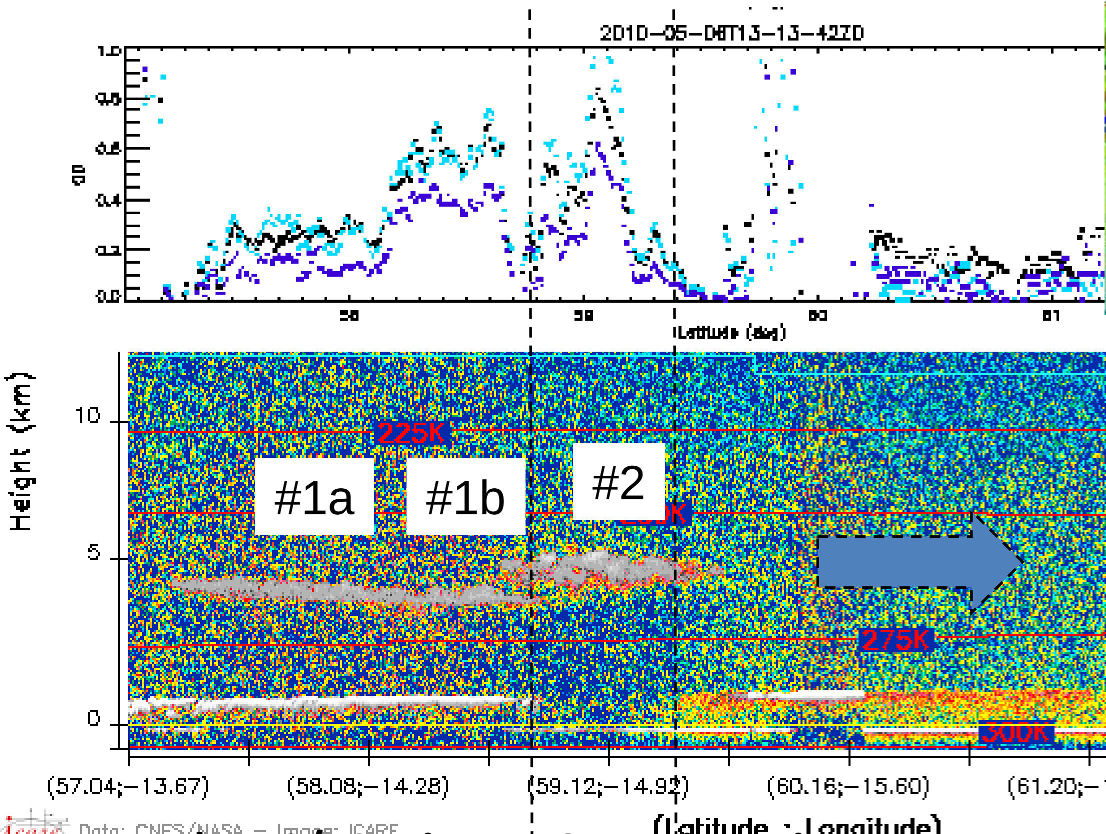
Aqua-MODIS on May 13 2010

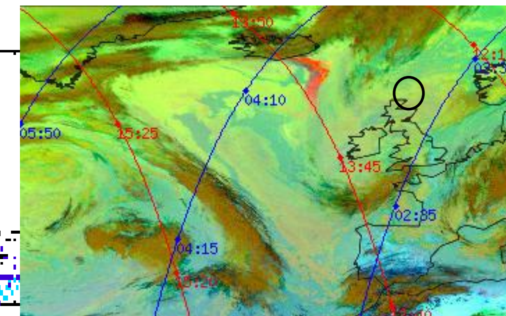
IIR VOLCANIC ASH ANALYSIS

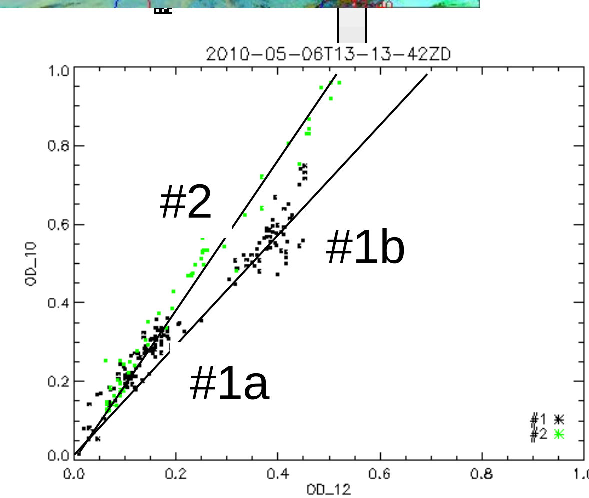
(J. Pelon, poster # 221)

Use of Level 1 (BTDs) + level 2 (ODs)
For the identification and characterization of Ash particles

6 May 2010







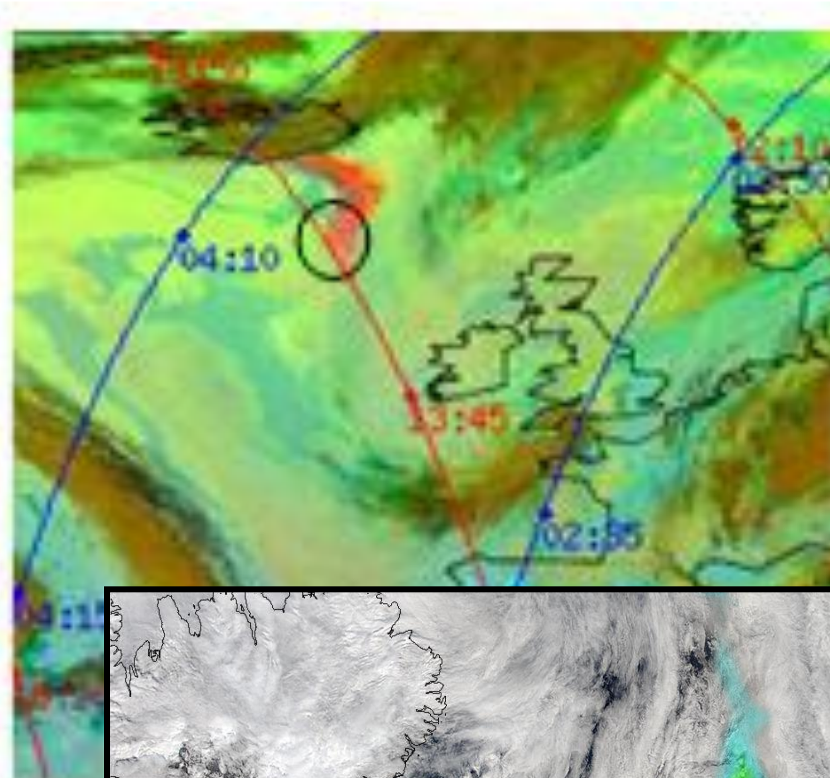
IR signature: the 10/12 microns OD ratio varies between 1,4 et 2 (green part # 2)

De = 5,2 µm (#1)
De = 4,5 µm (#2)

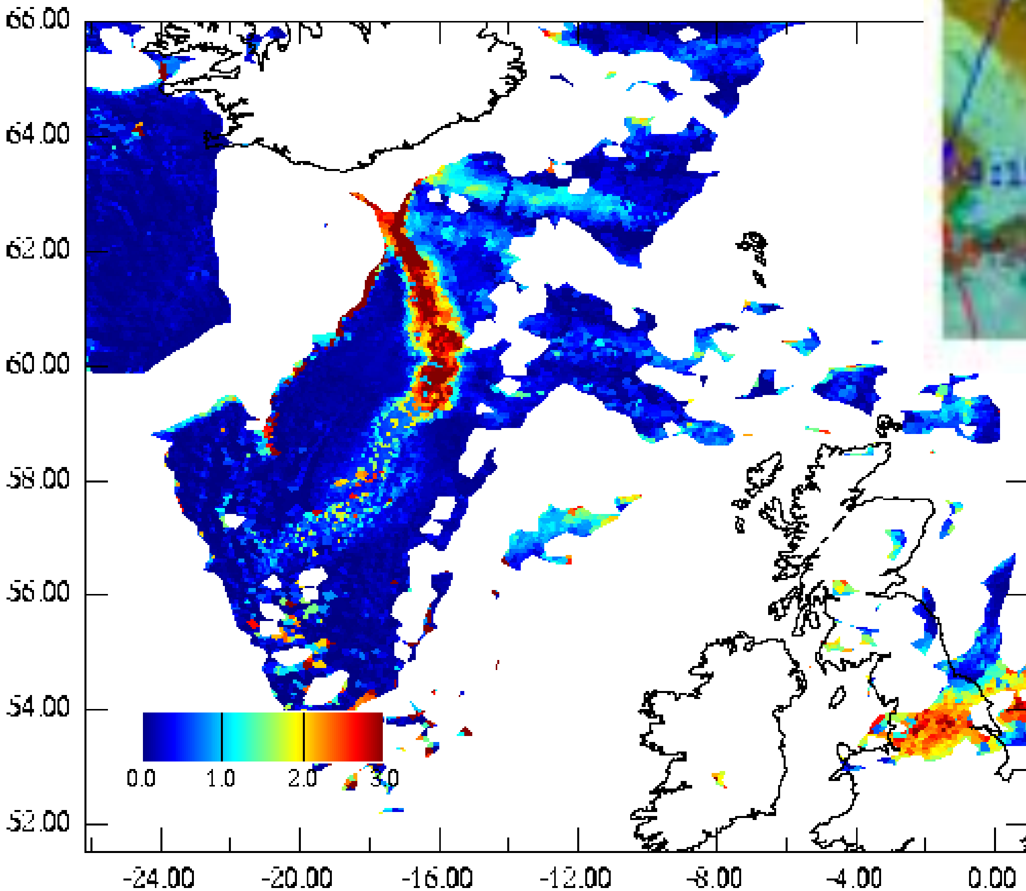
(Mie + indices for andesite)

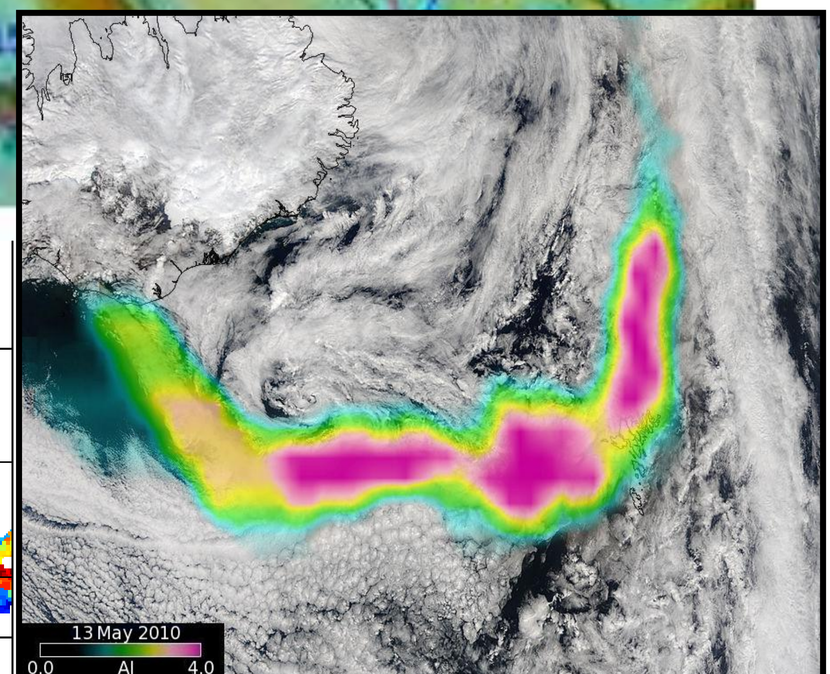
6 May 2010

IIR



PARASOL 8 May 2010: AOD

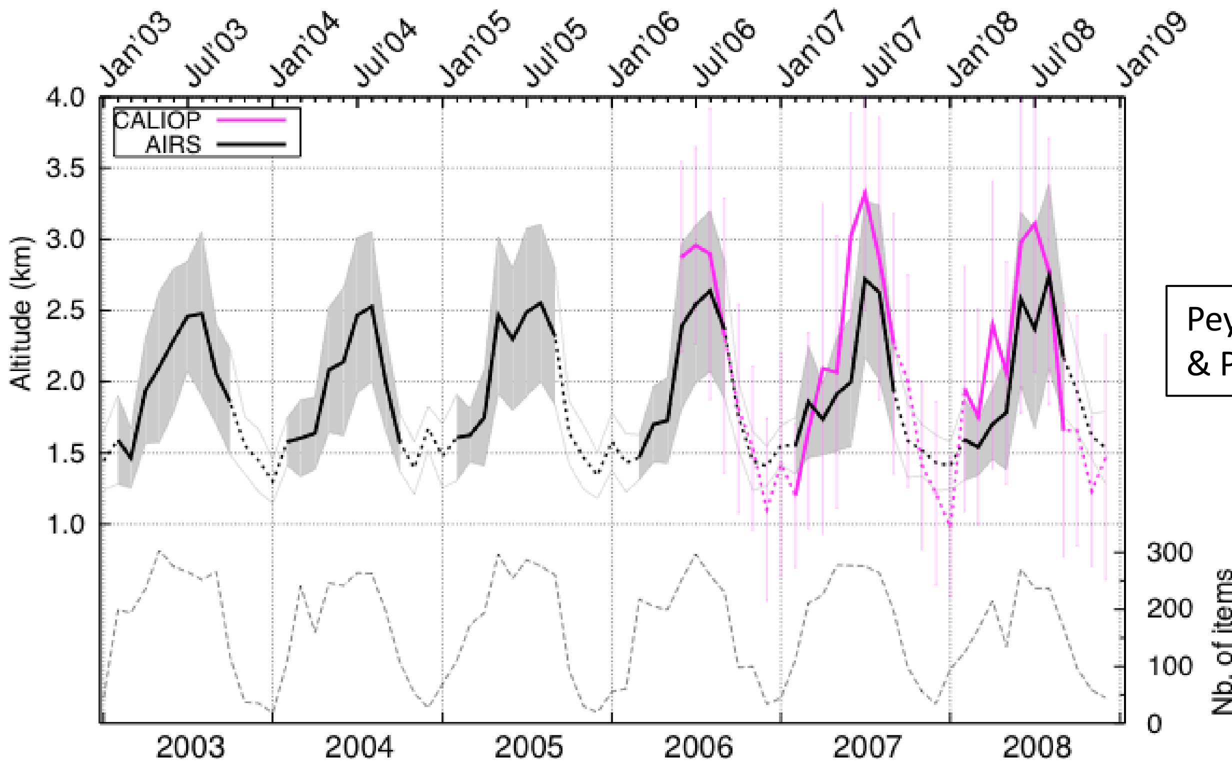


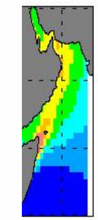


OMI on May 13 2010: AI

Trans-Atlantic Dust Transport from Multi-Sensors and Model (2003-2007 climatology – Summer JJA)

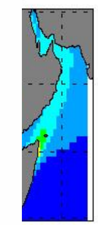
Total dust AOD @mid-visible



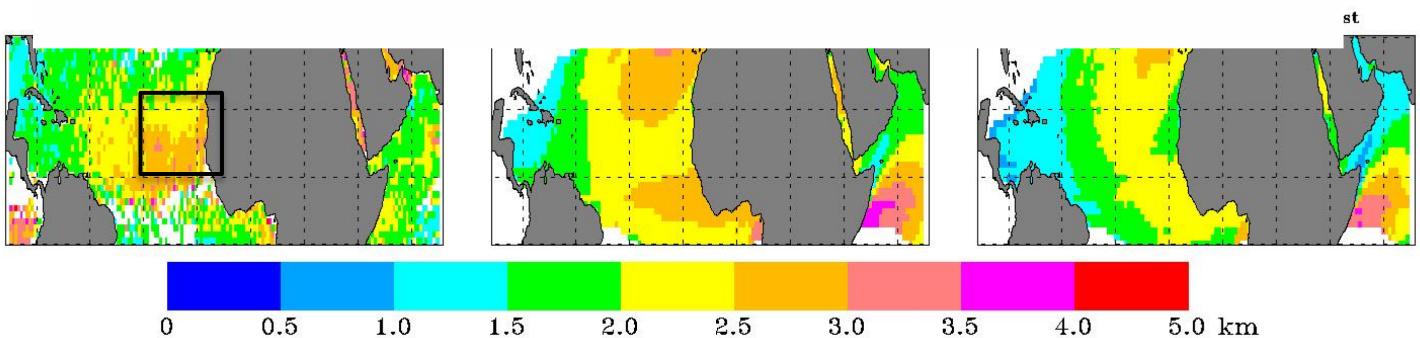


Peyridieu et, 2009
& Poster #225

Coarse-mode dust AOD



Dust Layer Centroid Height (CH)



From Hongbin Yu

CONCLUSION

• Huge improvements have been made with the A-Train data for the 3D representation of aerosol field (2D aerosol type and AOD, altitude of the layer, etc) – cloudy sky

• Satellite intercomparisons provide a robust way to test for unanticipated retrieval error or to understand the limits of a specific scheme/or instrument (retrievals from the UV to the TIR).

• Synergy between instruments just started :
  - overlapping and complementary capabilities in terms of retrieved quantities (AOD, Altitude, ω)
  - Unanticipated synergy : CLOUDSAT/CALIPSO, etc

• Development of new algorithms is very promising (can consider all measurements in a single inversion).